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PHYSICAL PERFORMANCE CHARACTERISTICS OF MILITARY AIRCRAFT MAINTENANCE PERSONNEL RESISTANT TO WORK-RELATED MUSCULOSKELETAL DISORDERS OF THE HAND AND WRIST

by

DEANNA S. PEKAREK

THESIS

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of Wayne State University,

Detroit, Michigan

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Disclaimer

The views expressed in this thesis are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. government.

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Physical Performance Characteristics of Military Aircraft Maintenance Personnel Resistant to Work-Related Musculoskeletal Disorders of the Hand and Wrist

CHAPTER 1

INTRODUCTION

Problem Statement

Work related musculoskeletal disorders (WMSD), the largest portion of reported and compensated work-related diseases, represent at least one-third of all reported occupational diseases in the United States, Nordic countries, and Japan. WMSDs are responsible for more work absenteeism and disability than any other disease category in the United States, Canada, Sweden, Finland, and England (Punnett & Wegman, 2004). Service industries accounted for 71% of all WMSDs with lost workdays in 2003 for the United States (US). Trade, transportation, and utilities; education and health services; and repair and maintenance are common service industries (Bureau of Labor Statistics [BLS], 2005).

Within the United States Air Force (USAF), electrical and mechanical repair technicians comprised the largest occupation category in the USAF or 21% of the enlisted workforce ("Air Force enlisted demographics", 2006 June). Aircraft maintenance was the duty area resulting in the largest number of lost workdays for the USAF from fiscal years 1993 through 2002 (Copley, Burnham, & Shim, 2003).

Identified job tasks for military aircraft maintainers include using aircraft controls and displays to determine the operational condition of aircraft, interpreting aircraft system characteristics to isolate malfunctions, and using functional tests to check hydraulic, electrical, and structural systems. Personnel in this career field remove, install, perform and supervise operational checks on external electronic equipment. A variety of tools, equipment, and parts are used to accomplish these duties. These tools and parts range from small hand tools to 400-pound wing flaps (J. Warsinske, personal communication, July 6, 2006). From this description, aircraft maintenance is clearly a hand-intensive occupation.

According to the National Safety Council (2002), 53% of WMSDs occurred at the wrist and another 23% at the hand and fingers. Upper extremity injuries or illnesses accounted for 29% of the lost workdays for maintenance workers with about 20% attributed to the wrist, hand, or finger (BLS, 2005).

Inflammatory, nerve compression, and degenerative conditions such as tendonitis, carpal tunnel syndrome, and arthritis are included in the category of WMSDs. Risk factors such as repetition, vibration, awkward positions, weather extremes, and force have been identified in the research as highly correlated with the development of WMSDs (Hakkanen, Viikari-Juntura, & Martikainen, 2001a, 2001b; Punnett, Gold, Katz, Gore, & Wegman, 2004; Punnett & Wegman, 2004; Zetterberg & Ofverholm, 1999). A causal relationship between WMSDs and occupational risk factors has been widely accepted internationally due to the strength and frequency of these correlations (Punnett & Wegman, 2004). Current research, however, has not examined individuals in high-risk categories who do not develop such disorders. Identifying common characteristics of workers who remain healthy may aid the development of effective interventions and prevention of upper extremity WMSDs.

Purpose

The purpose of this study was to identify common characteristics of workers who do not develop WMSDs of the hand or wrist although they work in a high-risk occupation. Additionally, this study compared the characteristics of healthy aircraft maintainers to healthy non-maintainers. Specifically, the purposes of this study were to 1) identify common characteristics of healthy workers who do not develop WMSDs and 2) compare the characteristics of healthy aircraft maintainers to healthy non-maintainers.

Study hypotheses are:

1) Armed services personnel, both maintainers and non-maintainers, will demonstrate normal values of grasp and pinch strength, coordination, sensation and range of motion of the hand and wrist.

2) Healthy military aircraft maintenance personnel will demonstrate greater strength, dexterity, and sensory acuity than healthy military personnel in other career fields.

3) There will be no difference in range of motion measures of the hand and wrist between healthy military aircraft maintainers and other healthy military personnel.

CHAPTER 2

LITERATURE REVIEW

Relevant topics related to WMSDs, military maintainers, and physical performance characteristics are examined in this literature review. WMSD topics include the prevalence of, common conditions and risk factors for, and impact on physical performance characteristics. Demographic information about relevant armed services personnel, fitness requirements, and duties of aircraft maintainers within the military are explored. Finally, physical performance characteristics and methods of assessment are reviewed.

WMSD Prevalence

Musculoskeletal diseases account for one-third or more of all reported occupational diseases in the US, Nordic countries and Japan. In fact, WMSDs account for more work absenteeism and disability than any other disease category in the US, Canada, Sweden, Finland, and England (Punnett & Wegman, 2004).

A variety of costs are associated with WMSDS, including both tangible and intangible costs. Tangible costs include lost workdays, lost wages, decreased productivity, and workers' compensation costs. Decreased quality of life, inability to perform routine tasks, and insufficient rest are examples of intangible costs.

In the US, lost workdays are one measure often reported as an indicator of WMSD impact and prevalence. The US Bureau of Labor Statistics (2005) reported 1.3 million injures and illnesses in 2003 requiring time away from work beyond the day of the incident. Of these injuries, WMSDs accounted for 33% of the absences. While the median number of lost workdays for all cases in 2003 was eight days, musculoskeletal disorders typically resulted in more prolonged absences from work. For example, WMSDs such as carpal tunnel syndrome, wrist injuries and repetitive motion injuries resulted in 32, 17, and 22 days absence from work in 2003 respectively (BLS, 2005).

The incident rate for WMSDs in certain industries and occupations is three to four times greater than the overall injury occurrence. While twelve occupations had over 20,000 lost workdays due to work related injuries or illnesses in 2003, 71% of all WMSDs with lost workdays were reported in service industries. These industries included the industries of trade, transportation, and utilities; education and health services; and repair and maintenance (BLS, 2005).

Maintenance and repair services have been neglected in the literature, even though they are included in the occupational category reporting the highest number of WMSDs. In 2003, general maintenance and repair workers (excluding automotive mechanics) reported an average of 13 lost workdays. This was the second highest number of median days away from work for all service occupations (BLS, 2005).

Hand-intensive occupations are correlated with a high prevalence of upper extremity WMSDs (Punnett & Wegman, 2004; Sande, Coury, Oishi, & Kumar, 2001; Tanaka, Petersen, & Cameron, 2001). Given the intensive hand requirements of maintenance work, it is not surprising that upper extremity injuries or illnesses accounted for 29% of lost workdays for maintenance workers, with about 20% attributed to the wrist, hand, or finger in 2003 (BLS, 2005).

Age and years of service are also correlated with lost workdays. Individuals aged 25 to 54 years reported the most lost workdays in 2003 for service occupations. In the mechanical and repair service occupations, workers aged 25 to 44 years accounted for about 50% of lost workdays. An additional 20% of lost workdays were shown by mechanical and repair workers aged 45 to 54 years. Fewer years of service were correlated with increased injury rates, as employees with one to five years of service were the most likely to miss work due to injury or illness. In the mechanical and repair service occupations, workers with one to five years experience represented 37.2% of the lost workdays (BLS, 2005).

WMSD symptoms and functional impact

A variety of conditions are encompassed in WMSDs. These are divided into the general categories of inflammatory, nerve compression, and degenerative conditions. Common inflammatory disorders include tendonitis, trigger finger, and tenosynovitis. Nerve compression conditions include carpal tunnel syndrome and ulnar neuropathy. Arthritis is an example of a degenerative condition.

Though exact symptoms vary by conditions and the individual, some are common to most WMSDs. These symptoms include pain that increases with movement, decreased range of motion, stiffness, loss of sensation, decreased strength, and swelling in the affected area. Often symptoms disturb sleep resulting in fatigue on the job and during all daily tasks (Rider, 2003; Sande, Coury, Oishi, & Kumar, 2001).

The impact of WMSDs on grip strength has been demonstrated. Maximum grip strength and pinch force during task performance has been shown to decrease as the severity of the WMSD increases (Sande, Coury, Oishi, & Kumar, 2001). As a result of decreased force capabilities, workers tend to overcompensate by using greater force than necessary during grasp tasks. For example, Lowe and Freivalds (1999) found that the grip force used to grasp and use hand tools was 54% greater than necessary in individuals with carpal tunnel syndrome. The ability to regulate pinch force decreased 12% in this same group of individuals. The authors suggested that sensory impairment; such as that experienced with carpal tunnel syndrome, influenced the ability to regulate exerted forces (Lowe & Freivalds, 1999). The combination of decreased maximum strength and difficulty regulating the amount of force being used negatively affects work and daily task performance. Additionally, as suggested by Lowe and Freivalds (1999), the higher forces exerted for task performance may contribute to progression of the condition.

Work related musculoskeletal disorders (WMSD) may be life changing for the injured person. Furthermore, the consequences of these disorders may not be eradicated when an individual changes jobs or the risk factors are decreased. Keogh, Nuwayhid, Gordon, and Gucer (2000) found that upper extremity WMSDs interfered with daily functioning up to four years after diagnosis. The majority of individuals (81%) reported less independence in work, home and leisure tasks than prior to the injury. Daily tasks were from categories of work, home, and leisure. Activities that required grip strength and coordination were consistently reported as difficult or unable to perform. Examples of reported activities included pushing up from a chair, lifting a child, and writing. Thirty-eight percent of all participants reported being laid off, fired, or quitting a job held at the time of the injury due to the WMSD. The loss of independence and the challenges that accompany it are examples of the intangible costs of WMSDs.

Risk factors

Musculoskeletal disorders (MSD), as defined by the US Department of Labor, are any injuries or disorders to the muscles, nerves, joints, tendons, cartilage, or spinal discs not caused by a slip, trip, fall or accident resulting in acute trauma (BLS, 2005). MSDs have a mixed etiology and are considered work-related when exposure to multiple risk factors occurs in the job setting. These risk factors include repetitive movements, forceful exertions, non-neutral postures (twisting, bending of wrist), vibration, and all combinations of these factors (Bernard, 1997; Punnett & Wegman, 2004; Tanaka, Petersen, & Cameron, 2001).

Studies have identified the attributable fraction for exposure to certain risk factors. The attributable fraction is "an estimate of the proportion of the disease that would be reduced in the exposed population if the exposure were eliminated." It indicates the relative importance of reducing the risk factor in settings with high exposure rates (Punnett & Wegman, 2004). Vibration, repetition and force, and repetition and cold had the three highest attributable fractions for upper extremity disorders with respective percentages of 44-95%, 88-93%, and 89% (National Research Council as cited in Punnett and Wegman, 2004). Due to these repeated findings, a causal relationship between MSDs and occupational risk factors has been widely accepted internationally (Punnett & Wegman, 2004).

Automotive stamping and assembly facilities have been extensively studied throughout the world and the incidence of WMSDs in the hand and wrist in correlation to accepted high-risk factors examined. Hand and wrist WMSDs symptoms were consistently found to be the most prevalent and persistent in these automotive facilities. One study found about 10% of individuals developed symptoms of an upper extremity WMSD within one year. This same study showed a 59% persistence rate for upper extremity WMSDs. Risk factors involved in these studies were awkward postures, fast work pace, vibration, and manual and static forces (Bernard, 1997; Punnett, Gold, Katz, Gore, & Wegman, 2004; Tanaka, Petersen, & Cameron, 2001; Zetterberg & Ofverholm, 1999).

These same studies also identified potential confounding or contributing factors to the development of WMSDs. These included age, the presence of systemic diseases such as diabetes or rheumatoid arthritis, obesity or high body mass index, pregnancy, gender, and smoking (Bernard, 1997; Punnett, Gold, Katz, Gore, & Wegman, 2004; Punnett & Wegman, 2004; Tanaka, Petersen, & Cameron, 2001; Zetterberg & Ofverholm, 1999). Evidence to support these factors was inconsistent between studies and did not establish causal relationships (Bernard, 1997; Tanaka et al., 2001; Punnett, Gold et al., 2004, Zetterberg & Ofverholm, 1999).

The relationship between job experience and WMSDs is unclear. Several studies have found inexperience correlated with a high level of injury or illness. Inexperience was typically identified as less than five years in the occupation. Common measures used in determining the correlations were reported WMSDs and resultant sick days. The highest incidence of each was shown to occur in the first three years in occupations with high risk factors for WMSDs such as construction or assembly. Wrist and hand symptoms were reported by 42.4% of apprentices in one study. The most frequently reported risk factors resulting in symptoms were high workload and static postures for extended time periods (Hakkanen, Viikari-Juntura, & Martikainen, 2001a, 2001b; Merlino, Rosecrance, Anton, & Cook, 2003).

Experienced workers may have consciously or unconsciously learned techniques to maintain health. For example, experienced butchers utilized a variety of equally protective movement strategies when performing a low force repetitive cutting task as compared to healthy workers new to the task. The authors suggested that incorporating varying movement strategies might have helped prevent WMSDs in experienced workers (Madeleine, Lundager, Voigt, & Arendt-Nielsen, 2003).

US Air Force (USAF) Demographics

In the most recent study ("Active duty demographic profile", 2005, September), active duty Air Force (ADAF) personnel ranged in age from 18 to 50 years with 45.35% being 22 to 30 years of age. The ADAF enlisted population was 80% male, 71.3 % between the ages of 20 to 34 years with 54.7% having between one and nine years of service time and 38.4% are between one and five years of service. Electrical and mechanical repair technicians accounted for 21% of the enlisted workforce in the USAF. It was the largest primary occupation category in the USAF ("Air Force enlisted demographics", 2006 June). This population is consistent with the age range and occupation categories reporting the most WMSDs and a high number of lost workdays as discussed previously.

Aircraft maintainers use aircraft controls and displays to determine the operational condition of aircraft and interpret aircraft system characteristics to isolate malfunctions. Personnel routinely use functional tests to check hydraulic, electrical, and structural systems. Aircraft maintenance professionals remove and install avionic system components and perform alignment, calibration, and scoping of avionic systems. Personnel in this career field also remove, install, perform and supervise operational checks on external electronic equipment ("Manned aerospace maintenance career field", n.d.).

A variety of tools, equipment, and parts are used to accomplish aircraft maintenance duties. Commonly used tools are hand tools weighing one to three pounds. Parts range from small to very large, requiring more than one person to move and position the part correctly. Parts and components that are lifted individually range from nuts, bolts, and screws weighing just ounces to seats, floorboards, and navigation tables/suites weighing 35 to 50 pounds. A team effort is used for large components for which no mechanical assist is available. These parts include 150 pound engine cowlings, stabilizer actuators of 200 lbs, in- and out-board ailerons at 150 to 200 pounds, and 400-pound main wing flaps. Maintenance requiring these parts are not daily tasks and are completed by two to four people depending upon the part and the access area (J. Warsinske, personal communication, July, 6, 2006).

Air Force WMSD injury data

Two jet engine repair/maintenance facilities, one at Langley Air Force Base and one at Seymour Johnson Air Force Base, were assessed for ergonomic risk factors in 1996. These facilities were responsible for receiving, inspecting, and repairing jet engines, tasks that are comparable to the duties of the aircraft maintainers studied in this thesis. Upper extremity risk factors were identified and assigned a high score for both facilities, placing them in a "problem job/process" category (Earth Tech, 1996, December 17). Identified task components that contributed to more than half of the rating included repetition of the same or similar motions every few seconds, hand force or grip over 19 pounds, awkward position of the wrist, and rapid forearm rotation (King & Butler, 1996; Schorn, 1996). As previously discussed, these risk factors are strongly associated with WMSDs of the wrist and hand (Punnett & Wegman, 2004; Bernard, 1997).

Copley, Burnham, and Shim (2003) completed a review of all reported USAF lost workday injuries from fiscal years 1993 through 2002. Aircraft maintenance was the duty area resulting in the largest number of lost workdays. Handling items and equipment, the use of hand tools, and the use of power tools were consistently among the top 10 work related causes of lost workday injuries. In October 2002, musculoskeletal disorders (MSD) were the leading cause of individuals being placed on light duty. Hand and wrist injuries were responsible for 20.4% of the injuries requiring more than one medical appointment and 11.6% of injuries resulting in duty limitations in the USAF for October 2004 (Army Medical Surveillance Activity, 2004).

Taken together, these findings suggested that the prevalence and impact of, and risk factors for WMSDs in Air Force aircraft maintainers are consistent with the general repair and maintenance population outlined previously. Additionally, these injuries had the same tangible and intangible costs to the USAF and its personnel as found in industry elsewhere.

Military Health and Fitness Regulations

All USAF personnel, active duty or reservists, must meet a fitness and weight standard, outlined in "Air Force Instruction 10-248 Fitness program", (2005, May 28), to enter and remain a member of the military. A fitness test and medical screening must be completed prior to acceptance into the USAF or any military service. After entrance into the military, medical evaluations and physical fitness tests are performed annually to determine an individual's ability to continue his or her service.

Several medical conditions are identified as disqualifying for an individual to join any branch of military service (*Department of Defense Instruction 6130.4 Medical Standards for Appointment, Enlistment, or Induction in the Armed Forces, 2005*). Disqualifying conditions include diabetes mellitus, rheumatoid arthritis, chronic inflammatory disorders, hypertension, and significant limitations in range of motion or sensation due to prior trauma. Contagious diseases and medical conditions or defects requiring excessive lost duty time for treatment also prohibit individuals from entering into military service. Candidates must be medically capable of completing all required training and performing all assigned duties without aggravating any existing medical conditions or physical defects. Being adaptable to a military environment without geographical area limitations is the last general criteria.

AFI 10-248, Fitness Program (2005) outlines the ongoing fitness requirements for Air Force and Air National Guard personnel. The annual physical fitness evaluation consists of height and weight measurements (used to determine body mass index), abdominal circumference measurement, the number of push-ups and sit-ups each performed in one minute, and a timed 1.5 mile run. A score for each component is obtained and summed to determine the overall fitness rating. Rating categories are poor, marginal, good, and excellent. If a service member scores in the marginal or poor fitness levels, he or she is immediately placed on a fitness program, must attend healthy lifestyle training, and be retested within 45 to 90 days. If the fitness score does not improve, administrative action may be taken up to and including reprimands or discharge from the USAF.

These regulations and instructions provide a control for non-work related factors that may contribute to the development of WMSDs. It can be assumed that USAF personnel are more physically fit than the general population and that pre-existing conditions are not large contributors to WMSDs in military personnel.

Air Force personnel are exposed to ergonomic risk factors daily. The lost workday and injury trends for military maintenance personnel are consistent with the Bureau of Labor Statistics (2005) trends for maintenance and repair occupations in the general work population. Due to the inherent control of potentially confounding non-work related risk factors, a reasonable a priori assumption is that WMSDs occurring in the military are more closely related to work conditions than in the general population. The groups of interest can also be assumed to be at the same general fitness levels. These factors made military aircraft maintainers and personnel a cohesive sample for this study.

Performance Components

There are 27 bones and 39 muscles involved in hand function, making assessment of hand function challenging (Hepp-Reymond, Huesler, & Maier, 1996). Furthermore, multiple physical components underlie skilled hand performance. These physical performance components minimally include range of motion, strength, sensation, and dexterity.

Active range of motion is the amount of joint motion performed during voluntary joint movement (Horger, 1990). This component is necessary for positioning of the hand for effective tool use, reaching into engines to remove or install system components, opening or closing system compartments, and the use of diagnostic equipment. The most common tool used to measure joint range of motion is the goniometer. Goniometric measurements have been found to be highly accurate and reliable when performed using standardized procedures, especially when completed by an experienced evaluator (Bear-Lehman & Abreu, 1989; Clarkson & Gilewich, 1989; Horger, 1990; Marx, Bombardier, & Wright, 1999).

Muscle strength is the ability of the muscle to produce tension (Wadsworth, Krishnan, Sear, Harrold, & Nielsen, 1987). This component is vital for holding components for removal or installation, pushing toolboxes or ladders, climbing ladders, and tool use. Muscle strength, regardless of muscle group, is typically quantified by measuring the amount of force exerted on a force gauge. The "make" test of muscle strength requires the body segment of interest to exert a constant force on an external object such as the clinician's hand or a digital scale. A standardized muscle testing format using a quantitative dynamometer was established following procedures outlined in Clarkson and Gilewich (1989), Reese (1999), and Bohannon (1986, 1999). Reliability of quantitative muscle testing for upper limb muscles tested in this protocol has been identified (Andrews, Thomas, & Bohannon, 1996; Bohannon, 1997; Bohannon & Endemann, 1989; Leonard et al., 2003; van der Ploeg, Fidler, & Oosterhuis, 1991).

Grip strength is needed to manipulate tools, hold components, and obtain access to systems by opening applicable hatches. Grip strength is defined as the force resulting in flexion at all finger joints to grasp and hold an object into the palm and is measured using a hook grasp on a hand dynamometer. Three types of pinch are conventionally measured, including tip, lateral, and three-jaw pinches (see figure 1). These are required to maintain force on smaller objects.

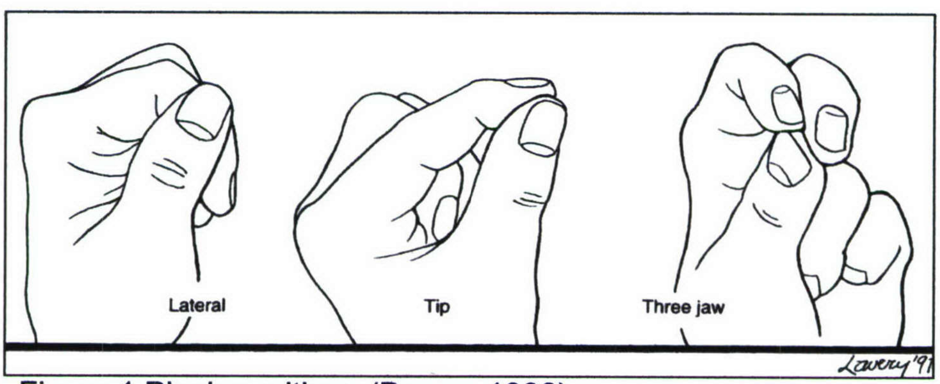

Figure 1 Pinch positions (Brown, 1998)

The ability to move digits into these positions, while exerting and sustaining pressure allows the technician to assemble nuts and bolts, feed wires or lines through a system, connect cables or testers to various system components, and turn dials. The standard Jamar™ dynamometer and pinch guage have high test-retest and inter-rater reliability (Bear-Lehman & Abreu, 1989; Haward & Griffin, 2002; MacDermid, Evenhuis, & Louzon, 2001; Marx, Bombardier, & Wright, 1999; V. Mathiowetz, 1990; V. Mathiowetz, Weber, Volland, & Kashman, 1984), and normative data has been established by age, gender, and hand dominance (Bohannon, Peolsson, Massy-Westropp, Desrosiers, & Bear-Lehman, 2006; V. Mathiowetz, 1990; V. Mathiowetz et al., 1985; V. Mathiowetz, Rennells, & Donahoe, 1985; V. Mathiowetz, Weber, Volland, & Kashman, 1984; Spijkerman, Snijders, Stijnen, & Lankhorst, 1991).

Efficient hand function depends upon the integration of sensory and motor abilities. Due to this interdependence, sensory changes are often noticed before motor changes in conditions such as nerve entrapments (Bear-Lehman & Abreu, 1989). Two-point discrimination has been correlated with effective hand function and accuracy of movement (Novak, Mackinnon, & Kelly, 1993; Rao & Gordon, 2001). Static two-point discrimination measures the density of slowly adapting nerve fibers or receptors in the hand and is considered a predictor of precise movement. Dynamic two-point discrimination tests the response of the quickly adapting nerve fiber system and predicts manipulation skills (Aszmann & Dellon, 1998; A. L. Dellon, 1978, 1984; A. L. Dellon & Kallman, 1983; Novak, Mackinnon, & Kelly, 1993). Sensation is especially important in tasks where vision is occluded, such as starting a nut on a bolt on the underside of an engine. Standard testing procedures have been established for two-point discrimination. Reliability and validity have also been established (Aszmann & Dellon, 1998; Bear-Lehman & Abreu, 1989; Crosby & Dellon, 1989; A. L. Dellon, 1978; A. L. Dellon, 1997; A. L. Dellon, Mackinnon, & Crosby, 1987; E. S. Dellon, Keller, Moratz, & Dellon, 1995; Mackinnon & Dellon, 1985; Novak, 2001; Novak, Mackinnon, Williams, & Kelly, 1993).

Dexterity, or the skill and ease of manipulating relatively small objects with the hands, is required for functional tasks such as writing, picking up washers, starting nuts on bolts, and operating compartment latches. The parameters used to assess dexterity are accuracy and speed (Bear-Lehman & Abreu, 1989; Marx, Bombardier, & Wright, 1999; Tiffin, 1998). The Purdue Pegboard™ has been shown to be a valid and reliable test of dexterity when standardized evaluation methods are followed and normative data for work populations is available (Bear-Lehman & Abreu, 1989; Buddenberg & Davis, 2000; Haward & Griffin, 2002; Marx, Bombardier, & Wright, 1999; Shahar, Kizony, & Nota, 1998; Tiffin, 1998).

The combined components of range of motion, strength, sensation, and dexterity make possible the skilled, precise movements required for aircraft maintenance. It is not currently known whether any individual performance component is correlated with ongoing upper extremity, wrist and hand health in aircraft maintainers. A better understanding of the performance components of healthy maintainers may provide a first step in the development of guidelines to maintain upper extremity health and prevent injury in future aircraft maintainers.

CHAPTER 3

METHODS

The Human Investigation Committee of Wayne State University approved this study (see Appendix A). The unit commander, supervisors, and the researcher recruited and pre-screened volunteers for inclusion criteria such as fitness test scores and medical status. Recruitment was accomplished through e-mail, at regular staff meetings, and through personal contacts. A point of contact for each group (maintainers and non-maintainers) was assigned to assist with participant recruitment and scheduling of test times.

Participants

Participants were military personnel assigned to Selfridge Air National Guard Base. Participants were either active or traditional reservists in the Air Force or Air National Guard. Active reservists were part of the active reserve component. These individuals performed the same maintenance duty during the week as a civilian and on military drill weekends as a reservist. Traditional reservists worked at a civilian job during the week and in their military duty only during reserve drill times. Participants were assigned to groups according to their career field. Those in a maintenance field were placed in the maintainers group. Individuals in any other career field were placed in the non-maintainer or control group.

Inclusion criteria for both groups were: (1) a score of "good" or better on the most recent annual military physical fitness evaluation, (2) healthy, (3) at least five consecutive years working in their respective career field, and (4) no history of injuries or disorders affecting hand function. The non-maintainers were age- and gender- matched with the maintainers.

The researcher screened all participants for inclusion by asking questions regarding military status, time in career field, and any history of disorders or injuries effecting hand function. If the individual was appropriate for the study, the researcher explained the purpose and procedures. If the individual was interested in participating, he signed and dated an informed consent form (see Appendix B).

Testing Protocol

The testing was presented in the following nonrandomized order: range of motion, wrist strength, dexterity, sensation, and grip and pinch strength. Tests were arranged to allow participant comfort and adequate rest between strength components. Testing was completed in a single 60-minute session at Selfridge Air National Guard Base.

Active range of motion measurements were obtained with goniometers. Standardized protocol for positioning was followed (Biometrics Ltd, 2002; Clarkson & Gilewich, 1989; Horger, 1990; Marx, Bombardier, & Wright, 1999) and the data was collected automatically with the Biometrics E-Link Evaluation System™ (see figures 2 and 3 p. 21).

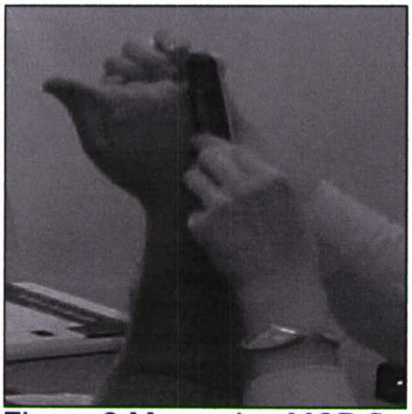
Figure 2 Measuring MCP flexion

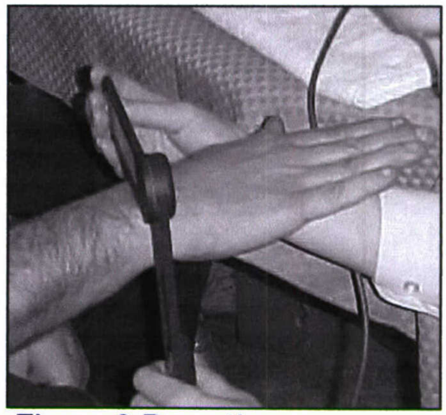
Figure 3 Pronation measurement

Strength of the composite wrist flexion and extension muscles was obtained using the Lafayette Manual Muscle Test System™, a quantitative muscle tester. The quantitative tester was set on high range for accurate readings from 0 to 300 lbs with a 0.4 lb resolution (*Lafayette manual muscle test system user's manual*). Resistance was applied according to standard protocol (Andrews, Thomas, & Bohannon, 1996; Bohannon, 1986; Bohannon & Andrews, 1987; Clarkson & Gilewich, 1989; Reese, 1999; Reilly & Walsh, 2005). The test time was set at five seconds with peak force recording occurring at about three seconds. (Andrews, Thomas, & Bohannon, 1996; *Lafayette manual muscle test system user's manual*). The readings were alternated between hands to allow a short rest period of approximately 30 seconds. Two readings for each muscle group were taken for each hand; all readings were within 15% of each other. The mean of the two scores was recorded.

The Purdue Pegboard™ was used to assess dexterity. All four subtests, right and left placing tests, bilateral placing, and bilateral assembly, were administered and scored following standardized procedures (Buddenberg &

Davis, 2000; V. Mathiowetz, Rogers, Dowe-Keval, Donahoe, & Rennells, 1986; Tiffin, 1998) (see figure 4).

Figure 4 Purdue pegboard™

Static followed by dynamic two-point sensation of the index finger were evaluated with a Disk-Criminator™. Standardized procedures were followed (A. L. Dellon, 1978; A. L. Dellon, 1997; A. L. Dellon & Kallman, 1983; Novak, 2001). Static sensation was tested on both the medial and lateral aspects of the index fingers. Static sensation was not possible in the presence of heavy calluses on the finger. Dynamic sensation was successfully collected for participants, as calluses were located on the sides of the digit and did not interfere with the dynamic sensation tests.

Grip and pinch strength were tested using standardized administration techniques (MacDermid, Evenhuis, & Louzon, 2001; V. Mathiowetz, 1990; V. Mathiowetz et al., 1985; V. Mathiowetz, Rennells, & Donahoe, 1985; Robertson, Mullinax, Brodowicz, & Swafford, 1996) with the commercial hydraulic dynamometer and pinch meter in the Biometric E-Link Evaluation System™.

Lateral, three-jaw, and tip pinch positions were tested. Standardized administration was followed for all (see figures 5 - 7). The data was collected automatically with the Biometric E-Link Evaluation System™. Three maximum isometric efforts were completed for each grip and pinch and the mean of the three trials was recorded.

Figure 5 Grip strength

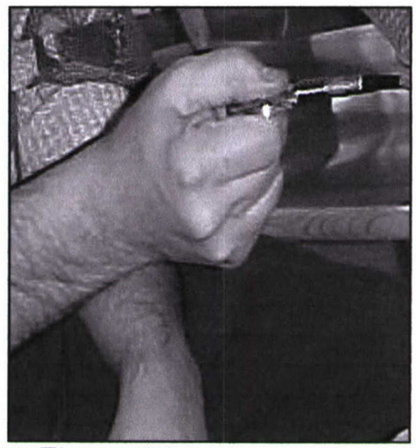

Figure 6 Lateral pinch

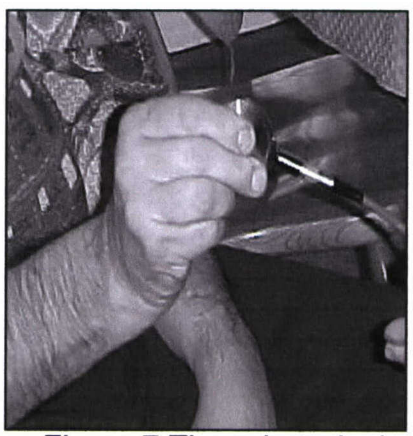

Figure 7 Three-jaw pinch

Data Collection and Analysis

Raw data was collected on a data collection sheet developed for this study (see Appendix C). Data was reviewed for accuracy prior to inclusion in the final data analysis. Descriptive statistics and between group comparisons for each characteristic were done using SPSS™ software. Multivariate analyses of variance were used to determine significance between groups for the dependent variables.

CHAPTER 4

RESULTS

The results of this study are reported here. It is organized by physical performance characteristics.

A total of 51 participants (23 maintainers, 28 non-maintainers) were recruited from units at Selfridge Air National Guard Base (see table 1 for demographic information). The maintainers group consisted of 23 participants. The mean age was 40 years with a range of 26 to 56 years. Time in the career field ranged from 5.5 to 32 years with a mean of 16.4 years. The 28 participants in the non-maintainers group had a mean age of 43 years (range 26 to 54 years) and 14.5 years was the mean time in the career field (range of 5 to 32 years).

TABLE 1

Group demographics

	Maintainers (n=23)	Control (n=28)
Mean Age (SD)	40 (8.75)	43 (8.08)
Mean Time in Field (SD)	16.4 (7.76)	14.5 (8.06)
R dominant/L dominant	18 / 5	25 / 3
ARC/TR	20 / 3	27 / 1
AF/ANG	23 / 0	27 / 1

SD = Standard Deviation, R = Right, L = Left, ARC = Active Reserve Component, TR = Traditional Reserve, AF = Air Force, ANG = Air National Guard

Most characteristics were reported on all 51 participants, however there were four exceptions (see Table 2 p. 26).

TABLE 2

Group number per characteristic

Characteristic	Maintainer	Control	Exclusion Reason
Strength – Wrist	23	28	
Strength – Grip	23	28	
Strength – Pinch	22	28	Pain in thumb
Dexterity	23	28	
Sensation	20	28	2 – calluses, 1 – frostbite
AROM – Wrist	23	28	

Strength

Several strength measurements were taken as part of the study. Strength categories were wrist flexion and wrist extension; bilateral grip; and bilateral pinch in the lateral, three-jaw, and tip positions. Means were determined and a between groups comparison was done for each strength category (see table 3).

Table 3

Strength (in pounds)

Mean (SD)	Maintainer Right	Non-Maintainer Right	*p*	Maintainer Left	Non-Maintainer Left	*p*
Wrist Flexion	85.80 (17.27)	83.76 (8.80)	.589	88.01 (18.40)	91.41 (10.25)	.408
Wrist Extension	96.94 (17.12)	101.34 (16.29)	.352	84.15 (13.56)	77.45 (13.39)	.083
Grip	120.20 (20.62)	116.04 (18.26)	.449	118.01 (21.32)	112.44 (16.49)	.298
Lateral pinch	23.84 (4.00)	23.66 (2.41)	.845	23.70 (4.38)	22.34 (2.54)	.175
3-jaw pinch	25.27 (4.80)*	22.41 (3.57)	.019	25.31 (6.57)	22.28 (4.53)	.060
Tip pinch	15.17 (3.75)	15.17 (2.31)	.998	14.36 (3.04)	14.25 (3.08)	.894

SD = Standard Deviation, * Significant at $p < .05$

The maintainers showed significantly better 3-jaw pinch strength in the right hand (p = .019) than the control group while the left 3-jaw strength approached significance at p = .060 (see Figure 8). All obtained values were consistent with the mean values identified by Mathiowetz, et al. (1985), and Bohannon, et al. (2006).

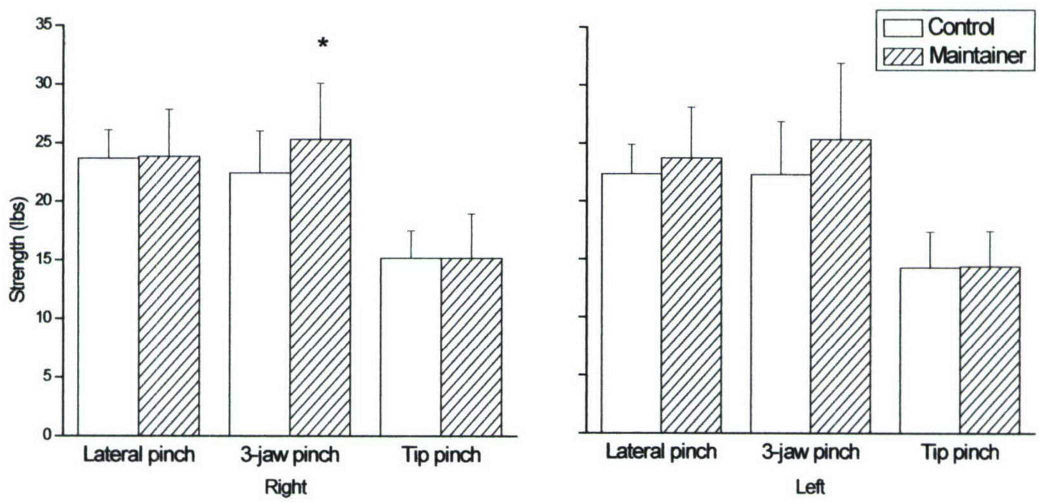

Figure 8 Pinch strength

Norms for wrist extension and flexion strength were not available. No significant difference was found between the two groups for wrist strength, grip strength, or lateral and tip pinch strength.

Dexterity

A total of 51 participants (28 non-maintainers, 23 maintainers) completed all subtests of the Purdue Pegboard™. Descriptive means were found for each group (see table 4 p. 28). There were no significant differences between the maintainers and non-maintainers for any subtest. Group means were slightly lower than available normative data but still fell within mean percentiles for all subtests as identified in the literature (V. Mathiowetz, Rogers, Dowe-Keval, Donahoe, & Rennells, 1986; Tiffin, 1998).

Table 4

Dexterity – Purdue Pegboard™ mean scores per subtest

Subtest	Maintainer (n=23)	Control (n=28)	Norm
Subtest 1/ Right hand (SD)	14.57 (1.95)	14.07 (1.82)	16
Subtest 2/ Left hand (SD)	13.48 (1.81)	13.93 (1.76)	15.5
Subtest 3/ Both hands (SD)	10.22 (1.88)	9.86 (1.63)	12
Sum 1, 2, 3 (SD)	38.04 (4.99)	37.61 (3.99)	46
Subtest 4/ Assembly (SD)	33.61 (4.96)	32.89 (4.7)	36.5

SD = Standard Deviation, Normative values from Lafayette Instrument Company, Table 13.

Sensation

Static and dynamic sensation measurements were taken on each index finger. Scores ranged from 2 mm up to 5 mm for static sensation and from 2 to 4 mm for dynamic sensation. The smaller distance indicates better sensation (see table 5 p. 29).

Significant differences were found with static 2-pt sensation along the medial aspect of the right index finger (p = .01) and the left finger both medial (p = .037) and lateral (p = .027) aspects. Maintainers showed better discriminative sensation than controls in all areas where significance was found (see figure 9 p. 29). No significant difference was found between the groups for static sensation on the medial aspect of the right index finger or for dynamic sensation.

Table 5

Sensation – Disk-Criminator™ (mean distance in mm)

Sensation subtest	Maintainer (n=20)	Control (n=28)	*p* value	Norm
Static R medial (SD) *	2.85 (0.59)	3.36 (0.68)	.010	2.3
Static R lateral (SD)	2.75 (0.64)	2.86 (0.65)	.574	2.3
Static L medial (SD) *	2.70 (0.57)	3.04 (0.51)	.037	2.3
Static L lateral (SD) *	2.55 (0.51)	2.93 (0.60)	.027	2.3
Dynamic R (SD)	2.50 (0.51)	2.79 (0.63)	.102	2.1
Dynamic L (SD)	2.65 (0.59)	2.71 (0.60)	.714	2.1

R = Right Index finger, L= Left Index finger, SD = Standard Deviation, * Significant at $p < .05$, Normative data for young adults from Crosby & Dellon (1989)

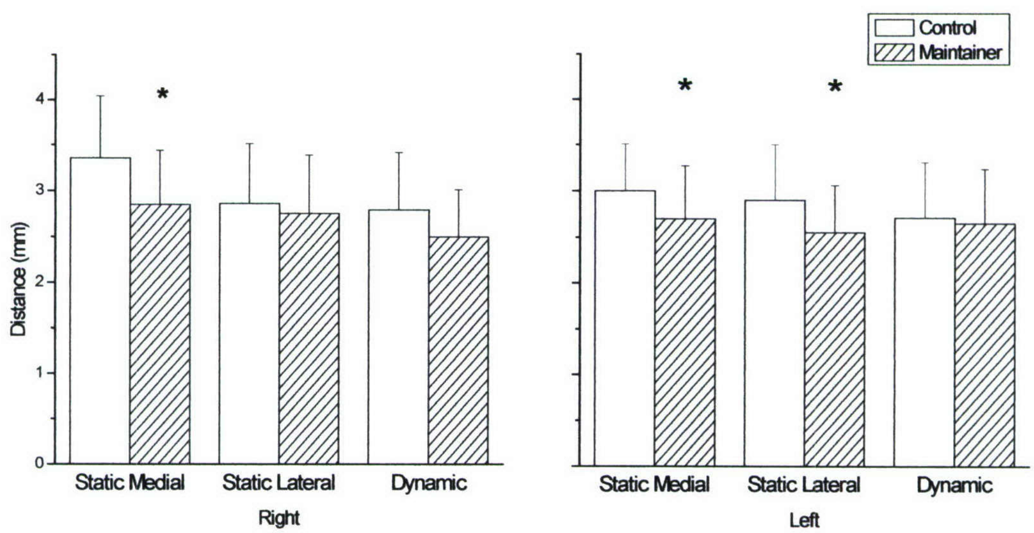

Figure 9 Two-point discrimination

Range of Motion

Range of motion measures were taken for the wrist, forearm, and digits. Total flexion and extension of each digit and total motion for each hand were used in the comparisons. Total motion of the digits was determined by adding total flexion and total extension for hand.

Descriptive means for each group were identified (see Table 6). Maintainers demonstrated greater right ulnar deviation when compared with normal ranges found in Clarkson and Gilewich (1989). No significant differences were noted between the groups for any other range of motion measure.

Table 6

Active Range of Motion

Joint motion (SD)	Maintainer Right	Non-Maintainer Right	Maintainer Left	Non-Maintainer Left	Normal Range
Wrist flexion	71.22 (10.29)	68.96 (8.53)	70.61 (9.56)	71.43 (10.60)	0 - 80
Wrist extension	67.09 (6.32)	67.46 (7.90)	69.65 (6.34)	70.36 (7.72)	0 - 70
Ulnar deviation	32.61 (6.29)	29.93 (6.28)	27.61 (5.30)	27.93 (5.99)	0 – 30
Radial deviation	20.00 (5.49)	19.68 (5.68)	19.17 (5.41)	18.39 (6.67)	0 – 20
Pronation	83.96 (4.79)	85.86 (4.62)	83.30 (4.79)	85.18 (3.51)	0 – 80
Supination	79.83 (4.71)	81.86 (6.17)	84.09 (4.16)	84.18 (5.00)	0 – 80
TM digits	1155.26 (47.91)	1161.86 (47.91)	1141.87 (72.71)	1153.50 (59.91)	Not Available

SD = Standard Deviation, TM = total motion, Normal range data from Clarkson & Gilewich, 1989

CHAPTER 5

DISCUSSION

Results of this study indicate that the sample groups, both maintainers and non-maintainers demonstrate physical characteristics, in general, that are comparable to mean available reference data. This suggests overall congruence between the sample groups and the general population. This finding is consistent with the first hypothesis, which stated that both groups would demonstrate normal values for grip and pinch strength, coordination, sensation, and wrist and hand range of motion.

There were three physical characteristics that differed between the two groups, with better performance shown by the maintainers as compared to the non-maintainers. These characteristics were right three-jaw pinch strength and static two-point sensation in the right and left index fingers. In addition, the maintainers demonstrated wrist ulnar deviation means that slightly exceeded normative values, although it was not significantly different from the control group.

Three-jaw pinch strength is frequently required when performing maintenance tasks. Tasks such as manipulating nuts, bolts, and small components, as well as connecting fuel and hydraulic lines require the use of the thumb, index and middle fingers to produce strong force in a three-jaw pinch position. The strength requirements of these tasks may explain the greater strength found in maintainers as compared to non-maintainers, as it is well accepted that muscle strength increases as a result of increased force requirements (Haward & Griffin, 2002; MacDermid, Fehr, & Lindsay, 2002). The non-maintainers use this pinch position for routine tasks such as writing which, although being frequently used, require less pinch force production.

Maintainers showed better static two-point sensation than non-maintainers on the index fingers except on the lateral aspect of the right index finger. The presence of excessive calluses in this area can impede tactile sensation, and may explain this difference between maintainers and non-maintainers. Overall, the maintainers demonstrated greater static sensory acuity than non-maintainers. As sensation cannot be enhanced with practice, it may be assumed that these individuals have better innate sensory acuity. Enhanced sensory acuity has been associated with improved movement accuracy (Rao & Gordon, 2001; Novak, Mackinnon, & Kelly, 1993) and ability to regulate force (Nakada & Dellon, 1989), especially with vision occluded. Better accuracy of finger, hand and arm movement may contribute to a more protective posture when working, fewer repetitions, and less time needed to complete a task. As awkward positioning, repetition, and time/duration are risk factors for WMSDs of the hand and wrist; enhanced sensory acuity may decrease these risk factors. As a result, sensory acuity may contribute to the resistance to WMSDs in aircraft maintainers.

Maintainers demonstrated greater ulnar deviation in the right, or dominant, wrist than is present in the general population. It is possible for ulnar deviation to slightly increase with repeated stretching of the joint capsule. Small amounts of incremental adaptive lengthening of muscles and other soft tissue structures can occur during routine tasks involving muscle loading and static holding in an extended position (Brody, 2005). Maintenance tasks may require a position of ulnar deviation frequently, especially when task space is constrained and/or manipulation is required from beneath the object, i.e., with the forearm supinated. Repetitive work in these situations may result in stretching of the wrist tendons and/or joint capsule, thus increasing the available range of ulnar deviation. However, as there was not a significant difference between the study groups, it is not clear if this adds to WMSD resistance or is a non-specific by-product of aircraft maintenance tasks.

The two groups did not show significant differences in all other measures of physical characteristics. These included strength (wrist, grip, lateral or tip pinch strength), dexterity, dynamic sensation, or active range of motion of wrist and finger flexion and extension. Measurements for these characteristics met or slightly exceeded available average norms. It may be that enhanced capabilities in these areas are not necessary for successful performance of aircraft maintenance tasks. However, at least average abilities in all these areas may be necessary.

A study by Madeleine, Lundager, Voigt, and Arendt-Nielsen (2003) found that healthy, experienced butchers used a variety of muscles and movement patterns to perform a repetitive cutting task. A standardized task was performed for three minutes at a rate of 12 task cycles per minute. The experienced butchers took more time planning their movement during precise steps but had a lower overall completion time. Interestingly, the experienced workers demonstrated a greater range of motion throughout task performance while incorporating a wide variety of shoulder and postural movement patterns. The authors suggested that these workers have developed a protective motor strategy that limited the development of pain syndromes.

This current study indicates that sensation and three-jaw pinch strength may be related to hand and wrist WMSD resistance. Individually, active range of motion, wrist strength, dexterity, and grip, lateral and tip pinch strength, do not appear to add to this resistance. It is likely that when performing tasks, maintainers utilize a combination of wrist, elbow, and shoulder musculature. Additionally, a variety of grip and pinch positions may be used. The variation in movement patterns coupled with enhanced sensation may allow task completion with average dexterity and normal range of motion. Enhanced sensation may also lend to maintainers applying more consistent and less overall force with repetitive gripping of tools and equipment. This may decrease the force and repetition needed to increase overall endurance and strength a significant amount. It may be the combination of these components in various patterns and protective postures that leads to the resistance to hand and wrist WMSDs. This supports the findings by Madeleine, et al (2003) and Lowe & Freivalds (1999).

Limitations

Study participants were from reserve and Air National Guard units at one Air National Guard Base. Though most participants were part of the active reserve component, the workload is less than an active duty unit. As high workload has been established as a factor in WMSD prevalence (Bernard, 1997; Merlino, Rosecrance, Anton, & Cook, 2003; L. Punnett, Gold, Katz, Gore, & Wegman, 2004; Rosecrance, Cook, Anton, & Merlino, 2002; Tanaka, Petersen, & Cameron, 2001; Zetterberg & Ofverholm, 1999), the sample may be less representative of active duty military aircraft maintainers and civilian aircraft maintenance personnel. Additionally, the age of active duty personnel differs from the sample in this study. The maintainers and non-maintainers had mean ages of 40 and 43 years respectively, whereas most active duty personnel are between the ages of 20 to 34 years. However, as physical characteristics are typically at their peak in young adulthood, one could expect that physical characteristics would be the same as or enhanced further in active personnel. Finally, the maintenance unit tested for this study was an air-refueling unit and worked on only one type of aircraft. Though general maintenance tasks remain the same, the available workspace, components, and frequency of tasks may vary between aircraft. These factors limit the application of this study to the active duty military aircraft maintenance population.

Only one grip position was tested in this study. The position tested is supported in the literature as being the best for obtaining a standardized grip strength reading (V. Mathiowetz, 1990; V. Mathiowetz et al., 1985; V. Mathiowetz, Weber, Volland, & Kashman, 1984). However, additional grip patterns may be required when performing maintenance tasks. It is also possible that the Purdue Pegboard™, while considered the "gold standard" for fine motor dexterity, did not accurately reflect the fine motor coordination requirements of aircraft maintenance tasks. The component parts included in the Purdue Pegboard™ are small and can be slippery. Finger size and calluses may impact the test scores (Haward &

Griffin, 2002; MacDermid, Fehr, & Lindsay, 2002). Also, these parts are smaller than anything typically used in aircraft maintenance.

Future directions

This foundational study suggests that identified characteristics, sensation and three jaw pinch strength are increased in military aircraft maintainers who have been resistant to hand and wrist WMSDs. Further research is needed to determine whether each characteristic, alone or in combination, is predictive of resistance to hand and wrist WMSDs.

Replication of this study is needed with active duty military aircraft maintainers and within a younger age range, in order to determine whether additional physical characteristics may impact resistance. Modifications to a replication study could include an additional coordination test, such as the Bennett Hand Tool test, that more closely matches the dexterity requirements of maintainers. Additionally, although norms are not available, grip strength testing using other hand postures is recommended (LaStayo & Hartzel, 1999).

Conclusion

Greater sensory acuity and three-jaw pinch strength were found to be physical performance characteristics that differentiated between non-maintainers and maintainers' who are resistance to hand and wrist WMSDs. These findings increase our understanding of characteristics common to persons resistant to WMSDs. As our understanding of the physical characteristics related to resistance increases, it provides a new lens for viewing our current WMSD prevention, and treatment strategies. Understanding resistance and the role played by various physical performance characteristics, may well provide the cornerstone for a new generation of prevention and treatment tactics.

APPENDIX A

EXPEDITED APPROVAL FORM

WAYNE STATE UNIVERSITY

HUMAN INVESTIGATION COMMITTEE
101 East Alexandrine Building
Detroit Michigan 48201
Phone: (313) 577-1628
FAX: (313) 993-7122
http://hic.wayne.edu

NOTICE OF EXPEDITED APPROVAL

To:	Deanna Pekarek Occupational Therapy	
From:	Francis LeVeque, D.D.S. Francis LeVeque Chairman, Human Investigation Committee	
Date:	February 06, 2006	
RE:	Protocol #:	0602003407
	Protocol Title:	Physical Performance Characteristics of Military Aircraft Maintenance Personnel Resistant to Hand/Wrist Musculoskeletal Disorders
	Sponsor:	
	Reference #1:	022906MP2E
	Reference #2:	
Expiration Date:	February 05, 2007	

The above-referenced Protocol and following information (if applicable) were APPROVED following Expedited Review (Category 4*) by the HIC Chairman for the Wayne State University Institutional Review Board (MP2).

- Flyer
- Consent Form (dated 1/31/06)

This approval does not replace any departmental or other approvals that may be required.

Federal regulations require that all research be reviewed at least annually. **It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.** You may not continue any research activity beyond the expiration date without HIC approval.

- If you wish to have your protocol approved for continuation, please submit a completed Continuation Form** at least six weeks before the expiration date. It may take up to six weeks from the time of submission to the time of approval to process your continuation request.
- **Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol on the expiration date. Information collected following suspension is unapproved research and can never be reported or published as research data.**
- If you do not wish continued approval, please submit a completed Closure Form** when the study is terminated.
- All changes or amendments to your protocol or consent form require review and approval by the Human Investigation Committee (HIC) **BEFORE** implementation.
- You are also required to submit a written description of any adverse reactions or unexpected events on the appropriate form (Adverse Reaction and Unexpected Event Form*) within the specified time frame.

*Based on the Expedited Review List, revised November 1998

APPENDIX B

RESEARCH INFORMED CONSENT

Research informed consent

Title of Study: Physical Performance Characteristics of Military Aircraft Maintainers Resistant to Hand/Wrist Musculoskeletal Disorders

You are being asked to be in a research study of physical performance components of the hand and wrist at Wayne State University and Selfridge Air National Guard Base. Please read this form and ask any questions you may have before agreeing to be in the study.

The study is being conducted by **Deanna Pekarek, OTR, Maj, USAF**.

Study Purpose:
The purpose of the study is to identify common physical performance characteristics of aircraft maintenance personnel who have not developed a musculoskeletal disorder of the hand or wrist after working in the career field for at least five consecutive years. The expected number of study participants to be enrolled at Selfridge Air National Guard Base is about sixty.

Study Procedures:
If you take part in the study, you will be asked to complete simple clinical measures of hand and wrist strength, range of motion, fine motor dexterity, and moving and static two-point sensation. All testing will be completed in one session of approximately 60 minutes. Component definitions and evaluation methods are:

a. Range of motion: The amount of movement in a joint in a particular direction within the limitation of the joint structure itself. Measured with a goniometer.
b. Wrist strength: The muscles' capacity to initiate, sustain, and control movement during a task. Wrist flexor and extensor strength will be measured with a quantitative muscle test, a type of force gauge.
c. Fine motor dexterity: The skill and ease of manipulating small objects. The purdue pegboard will be used. This consists of four subtest requiring the placement of small pegs into a board and the assembly of small parts on the same board.
d. Two-point sensation: Static discrimination enables you to know how tightly you are holding something. Dynamic discrimination is used when you identify something through touch. A Disc-Criminator will be used to test this. A random stimulation of one or two point will be applied to the fingertips and you will have to identify how many points you feel with each placement/stimulation.
e. Grip strength: The force produced by the flexion of all finger joints to grasp onto an object and hold it against the palm. This will be measured with a dynamometer, grip strength tester.
f. Pinch strength: The force produced in three functional pinch positions used for daily functions will be measured. A pinch force gauge will be used.

g. General demographic information such as age, gender, career field, time in field, military status, and service branch will be collected via interview. This information is for data analysis and categorization purposes.
h. No identifying information will be collected. You will be assigned an alphanumeric code such as M1 or C1.

Benefits:
There will be no direct benefits for you; however, information from this study may benefit other people with similar health issues now or in the future.

Risks:
By taking part in this study, you may experience the following risks:
- Physical risks: This research is expected to offer minimal physical risk, which may be seen in muscle aches or other unknown risks.

Research Related Injuries:
In the event that this research related activity results in an injury, treatment will be available including first aid, emergency treatment and follow-up care as needed. Care for such will be billed in the ordinary manner to you or your insurance company. No reimbursement, compensation or free medical care is offered by Wayne State University. If you think that you have suffered a research related injury, let the investigator know right away.

Study Costs:
- There will be no costs to you for participation in this research study.

Compensation:
- You will not be paid for taking part in this study.

Confidentiality:
All information collected about you during the course of this study will be kept confidential to the extent permitted by law. You will be identified in the research records by a code name or number. Information that identifies you personally will not be released without your written permission. However, the study sponsor, the Human Investigation Committee (HIC) at Wayne State University, FDA or federal agencies with appropriate regulatory oversight, may review your records.

Voluntary Participation /Withdrawal:
Taking part in this study is voluntary. You may choose not to take part in this study, or if you decide to take part, you can change your mind later and withdraw from the study. You are free to not answer any questions or withdraw at any time. Your decision will not change any present or future relationships with Wayne State University or its affiliates or other services you are entitled to receive. The investigator, or the sponsor, may stop your participation in this study without your consent.

Questions:

If you have any questions now or in the future, you may contact Deanna Pekarek at the following phone number (810) 326-2090. If you have questions or concerns about your rights as a research participant, the Chair of the Human Investigation Committee can be contacted at (313) 577-1628.

Consent to Participate in a Research Study:
To voluntarily agree to take part in this study, you must sign on the line below. If you choose to take part in this study, you may withdraw at any time. You are not giving up any of your legal rights by signing this form. Your signature below indicates that you have read, or had read to you, this entire consent form, including the risks and benefits, and have had all of your questions answered. You will be given a copy of this consent form.

Signature of Participant/ Legally Authorized Representative — Date

Printed Name of Participant/ Authorized Representative — Time

**Signature of Witness (When applicable) — Date

Printed Name of Witness — Time

Signature of Person Obtaining Consent — Date

Printed Name of Person Obtaining Consent — Time

** Use when participant has had consent form read to them (i.e., illiterate, legally blind, translated into foreign language).

APPENDIX C

RESEARCH DATA COLLECTION FORM

Data Collection Sheet

Participant Code _____

Age: _____ Gender: M / F Career Field: ____________ Time in field: ________
Shift: ____ Mil Status: AD / Res Branch: USAF / USA /USN /USMC /USCG /ANG

AROM:

AROM	Wrist √ / ⟋	u.d.	r.d.	pro	sup
R					
L					

Flex/Ext	R Th	R IF	R LF	R RF	R SF	L Th	L IF	L LF	L RF	L SF
MCP										
PIP										
DIP										

Wrist Strength: R Flex ______ Ext ______ L Flex ______ Ext ______

Dexterity: Subtest 1 (R Hand) _________ Subtest 3 (Both Hands) ________
(Purdue) Subtest 2 (L Hand) _________ Subtest 4 (Assembly) ________
Sum 1, 2 & 3 _________

Sensation: Static R ________ L ________
(2-point) Dynamic R________ L________

Grip: R ______ _______ _______ Ave _______
L ______ _______ _______ Ave _______

Pinch: Lateral R ______ _______ _______ Ave _______
L ______ _______ _______ Ave _______

3-jaw R ______ _______ _______ Ave _______
L ______ _______ _______ Ave _______

Neat/tip R ______ _______ _______ Ave _______
L ______ _______ _______ Ave _______

Notes:

____
____
____

APPENDIX D

ACRONYM LIST

Acronym List

ADAF ....Active duty Air Force

AFI ....Air Force Instruction

BLS ....Bureau of Labor Statistics

Col ....Colonel

MCP ....Metacarpophalangeal

MSD ....Musculoskeletal disorder

SMSgt ....Senior Master Sergeant

US ....United States

USAF ....United States Air Force

WMSD ....Work-related musculoskeletal disorder

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Suppliers

Evaluation System V900S; Biometrics Ltd, Post Office Box 340, Ladysmith, VA 22501.

Lafayette Manual Muscle Test System Model 01163; Lafayette Instrument, 3700 Sagamore Parkway North, Post Office Box 5729, Lafayette, IN 47903.

Purdue Pegboard Model 32020; Lafayette Instrument Company, Post Office Box 5729, Lafayette, IN 47903.

Disk-Criminator, Post Office Box 16392, Baltimore, MD 21210.

SPSS for Windows, version 9.0; SPSS Inc, 233 South Wacker Drive, Chicago, Il 60606.

ABSTRACT

PHYSICAL PERFORMANCE CHARACTERISTICS OF MILITARY AIRCRAFT MAINTENANCE PERSONNEL RESISTANT TO WORK-RELATED MUSCULOSKELETAL DISORDERS OF THE HAND AND WRIST

by

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Major: Occupational Therapy

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Work related musculoskeletal disorders (WMSD) account for the greatest number of reported work-related diseases. Aircraft maintenance, in the US Air Force, is the duty area with the most lost workdays. While several risk factors have been identified, characteristics of those in high-risk jobs that do not develop such disorders are not known. This study aims to identify sensorimotor characteristics of workers who have not developed WMSDs, and compare these physical characteristics of healthy aircraft maintainers to healthy non-maintainers. Fifty-one military personnel (23 maintainers and 28 non-maintainers) participated. Clinical measures of the hand and wrist included standardized assessments of strength, range of motion, dexterity, and sensation. Testing order was fixed. Maintainers slightly exceeded normative values for right wrist ulnar deviation. Means of all other characteristics were within accepted clinical values. Military

aircraft maintainers scored significantly higher than non-maintainers for static 2-point sensation and right 3-jaw pinch strength.

AUTOBIOGRAPHICAL STATEMENT

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Education:
Wayne State University, Graduate Certificate in Occupational Safety, Aug 2006
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- Sep 2004-Present, Graduate student, Air Force Institute of Technology
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- Dec 1996 – May 1999, Occupational Therapist, Educational & Developmental Intervention Services, Lakenheath AFB, United Kingdom
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Certifications/Licensure:

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Achievements:

- 2006 Barbara J. Henderson-Miller Scholarship recipient
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- Air Force Achievement Medal
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Professional Organizations:

- AOTA member since 1994
- WSU Alumni Association since 1996
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